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Title: Method and Apparatus for Granulating Saturated Polyester Resin

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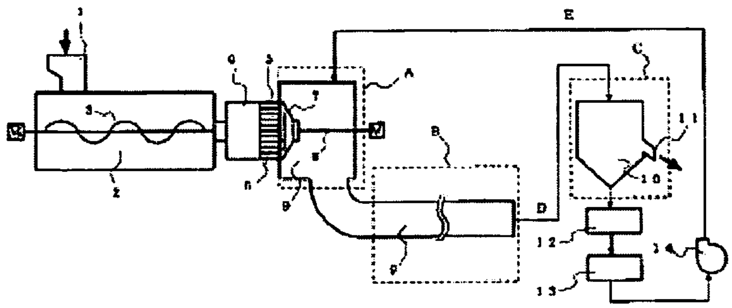
(54) [Title of the Invention] Method and Apparatus for Granulating Saturated Polyester Resin

(57) [Summary]

[Object] An object of the present invention is to provide a method and apparatus for granulating saturated polyester that allows saturated polyester resin to be granulated and the granulated pellets to be crystallized as a result of underwater cutting with little energy loss and excellent treatment efficiency in an insulation/crystallization zone provided to the granulating apparatus.

[Means of Achievement] A method for granulating saturated polyester resin, characterized in having a step for kneading and extruding saturated polyester resin; a step for cutting the molten saturated polyester resin that has been extruded into a heating medium, and working the resin into pellets in an insulation/crystallization zone provided to a granulating apparatus; a step for inducing crystallization by means of keeping the saturated polyester resin at a temperature that ranges from the glass transition temperature (Tg) thereof or higher to the melting point (Tm) thereof or lower in the temperature-controllable insulation/crystallization zone; and a step for removing the heating medium and drying the product; and an apparatus thereof.



[Claims]

[Claim 1] A method for granulating saturated polyester resin by means of using a granulating apparatus that operates on the underwater cutting principle, said method for granulating saturated polyester resin characterized in comprising a step for kneading and extruding saturated polyester resin; a step for cutting the molten saturated polyester resin that has been extruded into a heating medium and working the resin into pellets in an insulation/crystallization zone provided to the granulating apparatus; a step for inducing crystallization by means of keeping the saturated polyester resin at a temperature that ranges from the glass transition temperature (Tg) thereof or higher to the melting point (Tm) thereof or lower in the temperature-controllable insulation/ crystallization zone; and a step for removing the heating medium and drying the product.

[Claim 2] The method for granulating saturated polyester resin according to claim 1, characterized in that the saturated polyester resin is any resin selected from polyethylene terephthalate, polybutylene terephthalate, polyethylene naphthalate, polyester ether, and other such polyester resins.

[Claim 3] An apparatus for granulating polyester resin by means of using a granulating apparatus that operates on the underwater cutting principle, said apparatus for granulating polyester resin characterized in having means for kneading and extruding the saturated polyester resin; means wherein an insulation/crystallization zone is provided in communication with a die plate mounted at the distal portion of an extrusion die and wherein the molten saturated polyester resin that has been extruded into the heating medium of the insulation/crystallization zone from numerous small holes that open toward the turning face of a cutter knife adjacent to the front face of the die plate inside the insulation/crystallization zone in communication with the die plate is then cut with a cutter knife and worked into pellets; means for inducing crystallization as a

result of keeping the saturated polyester resin at a temperature that ranges from the glass transition temperature (Tg) thereof or higher to the melting point (Tm) thereof or lower in the temperature-controllable insulation/crystallization zone; and means for removing the heating medium and drying the product.

[Detailed Description of the Invention]

[0001]

[Technological Field of the Invention] The present invention relates to a method and apparatus for granulating saturated polyester using a system that operates on the underwater cutting principle, whereby saturated polyester resin is granulated and the granulated pellets are at the same time crystallized in an insulation/crystallization zone of the granulating apparatus that operates on the underwater cutting principle.

[0002]

[Prior Art] There been a tendency toward an increase in the amount of polyester used in the packaging field in response to environmental problems in recent years, and a need exists for wide-ranging viscosity properties that are in tune with diverse molding methods. For instance, the polyester resins that are used for the majority of films, including magnetic tape base film, and textile fibers generally have a limiting viscosity, which is a measure of the degree of polymerization, within a range of 0.5 to 0.6. On the other hand, the polyester resins that are used in crystallized polyester resin stretched sheets for bottles and trays must have a high degree of polymerization of 0.7 to 1.2. There are also cases where a regenerated saturated polyester resin from industrial waste is molded by means of injection, extrusion, or another molding means without crystallizing the polyester resin pellets. However, in this case there are problems in that pyrolysis will occur when the polyester is melted unless the pellets are pre-heated and dried as a result of being kept at about 160°C for four hours (to a water content of 10 ppm; bone dry) before molding. Therefore, an increase in the viscosity and molecular weight of regenerated polyester resins has accompanied the recycling of used containers and the like.

[0003] Solid-phase polymerization is an example of a means whereby the viscosity and molecular weight of a saturated polyester resin are raised as a result of a separate step once the polyester resin pellets have been formed using a granulating apparatus. This solid-phase

polymerization normally involves first introducing the so-called amorphous polyester resin pellets that have not yet been crystallized to a pre-crystallization tank and heating these pellets in the pre-crystallization tank to the glass transition temperature (Tg) of the resin or higher. The pellets begin to soften, become sticky, and can fuse together at this temperature. Therefore, they are treated for 0.5 hour with air or inert gas such as nitrogen that has been heated to approximately 170°C while being agitated in order to keep the pellets from fusing together and forming a hardened mass. The pellets that have been pre-treated in this way are fed through a preheating tank as necessary and are then fed to a solid-phase polymerization tank. The material is polymerized in a solid phase as a result of heating the system while air or inert gas is being circulated through the tank at a temperature of 200 to 230°C until the desired degree of polymerization is obtained.

[0004] A strand system is a commonly used as the granulating apparatus for granulating saturated polyester resins. As shown in Figure 2, for example, this apparatus has an extrusion die 18 that communicates with an extrusion head mounted on the distal portion of the extrusion cylinder of an extruder. Fine holes 20 are formed in the tip of the extrusion die 18. The molten, kneaded resin is extruded in strands.

[0005] A water chamber 23 that receives and cools the resin strands extruded from the fine holes 20 is disposed underneath the extrusion die 18. The cold water in the water chamber 23 is normally at a temperature of 20°C, and the water is fed through a cold fluid feed tube 24 to the water chamber 23 so that the chamber does not exceed a temperature of 80°C. The resin strands quenched in the water chamber 23 are cut with a cutter 21 into pellets. The resin pellets are discharged as amorphous pellets through a discharge port 22.

[0006] Next, in order to raise the viscosity and molecular weight of the polyester resin to specific values, the saturated polyester resin pellets obtained as described above are treated by, for instance, a separate step of solid-phase polymerization. An example of this apparatus is the vertical solid-phase polymerization device shown in Figure 3. This device has a solid-phase polymerization column 26 that consists of a combination of a vertical cylinder and an inverted cone for the base. The device is also provided with a saturated polyester resin pellet inlet 27, an inert gas feed port 31, an exhaust port 28, and a port 32 for discharging the pellets polymerized in the solid phase. The agitating section inside the device is composed of an agitating shaft 29 with multiple horizontal blades 30. Inert gas is first fed continuously to the device during solid-

phase polymerization. A specific amount of saturated polyester resin pellets is then introduced from the pellet inlet 27 as the agitating shaft 29 is being rotated. Once introduction of pellets is completed, the temperature of the inert gas being fed through the inert gas feed port 31 is gradually raised to a specific level. After the specific temperature level has been reached, the pellets continue to be heated at a final temperature until the saturated polyester resin pellets reach a specific degree of polymerization. Once this specific degree of polymerization has been reached, the inert gas that is being fed is immediately replaced with cold air, and the saturated polyester resin pellets are cooled to the prescribed temperature. The entire amount of solid-phase polymerized saturated polyester resin pellets is discharged from the pellet discharge port 32.

[0007] As previously described, separate steps are used in the conventional methods to granulate saturated polyester resin and to crystallize or otherwise treat the resin in order to raise its degree of polymerization. Moreover, ordinary solid-phase polymerization is used as the crystallization means or as the means to raise the degree of polymerization of the saturated polyester. However, there are problems with solid-phase polymerization in that the pellet surface is render rough as a result of the agitation that is performed to prevent the pellets from fusing together, and that the powder produced as a result of the pellets rubbing against each other during agitation interferes with the finishing treatment.

[0008] Moreover, the pellets are molded from saturated polyester resin and crystallized in two separate steps. This is disadvantageous in terms of energy loss and treatment efficiency.

[0009]

[Problems to Be Solved by the Invention] The present invention was devised in light of these problems, the object thereof being to provide a method for granulating saturated polyester that allows saturated polyester resin to be granulated and the granulated pellets to be crystallized with little energy loss and an excellent treatment efficiency in the insulation/crystallization zone of a granulating apparatus that operates on the underwater cutting principle.

[0010]

[Means Used to Solve the Above-Mentioned Problems] Aimed at addressing the above-mentioned problems, the invention relating to claim 1 is a method for granulating saturated

polyester resin by means of using a granulating apparatus that operates on the underwater cutting principle, the method for granulating saturated polyester resin characterized in comprising a step for kneading and extruding saturated polyester resin, a step for cutting the molten saturated polyester resin that has been extruded into a heating medium and working the resin into pellets in an insulation/crystallization zone provided to the granulating apparatus, a step for inducing crystallization as a result of keeping the saturated polyester resin at a temperature that ranges from the glass transition temperature (Tg) thereof or higher to the melting point (Tm) thereof or lower in the temperature-controllable insulation/crystallization zone, and a step for removing the heating medium and drying the product.

[0011] The invention relating to claim 2 is a method for granulating saturated polyester resin according to claim 1 characterized in that the saturated polyester resin is any resin selected from polyethylene terephthalate, polybutylene terephthalate, polyethylene naphthalate, polyester ether, and other such polyester resins.

[0012] The invention relating to claim 3 is an apparatus for granulating polyester resin as a result of using a granulating apparatus that operates on the underwater cutting principle, the apparatus for granulating polyester resin characterized in having means for kneading and extruding the saturated polyester resin, means wherein an insulation/crystallization zone is provided in communication with a die plate mounted at the distal portion of an extrusion die and wherein the molten saturated polyester resin that has been extruded into the heating medium of the insulation/crystallization zone from numerous small holes that open toward the turning face of a cutter knife adjacent to the front face of the die plate inside the insulation/crystallization zone in communication with the die plate is then cut with a cutter knife and worked into pellets, means for inducing crystallization as a result of keeping the saturated polyester resin at a temperature that ranges from the glass transition temperature (Tg) thereof or higher to the melting point (Tm) thereof or lower in the temperature-controllable insulation/crystallization zone, and means for removing the heating medium and drying the product.

[0013]

[Embodiments of the Invention] The present invention is characterized by a method for simultaneously granulating and crystallizing saturated polyester resin in the insulation/ crystallization zone of a granulating apparatus that operates on the underwater cutting principle,

this method for granulating saturated polyester resin having a step for kneading and extruding saturated polyester resin, a step for cutting the molten saturated polyester resin that has been extruded into a heating medium and working the resin into pellets in an insulation/crystallization zone provided to the granulating apparatus, a step for inducing crystallization as a result of keeping the saturated polyester resin at a temperature that ranges from the glass transition temperature (Tg) thereof or higher to the melting point (Tm) thereof or lower in the temperature-controllable insulation/crystallization zone, and a step for removing the heating medium and drying the product.

[0014] Examples of the saturated polyester that is granulated according to the present invention include polyethylene terephthalate, polybutylene terephthalate, polyethylene naphthalate, and polyester ether.

[0015] There are no special restrictions as to the granulating apparatus as long as it operates on the underwater cutting principle. However, it is preferably a granulating apparatus with one or two shafts having a continuous kneader.

[0016] Embodiments of the present invention will now be described based on the drawings. Figure 1 is an explanatory drawing that is shown in order to describe the step for granulating and crystallizing the saturated polyester resin of the present invention. The method and apparatus for granulating saturated polyester resin according to the present invention will be described based on Figure 1. A specific saturated polyester resin (in flake or powder form) and various additives are continuously fed through the starting material feed port 1 of the granulating apparatus that operates on the underwater cutting principle according to the present invention. The resin thus fed is kneaded with the aid of a screw 3 provided with a drive device M while melted in a kneading section 2. The granulating apparatus consists of an extrusion die 4 that communicates with an extrusion head attached to the distal portion of the extrusion cylinder of an extruder, an insulation/crystallization zone 9 consisting of a granulation section A and crystallization section B connected to the die 4 with the help of connecting bolts (not shown), and a cutter drive device M connected to the insulation/crystallization zone 9 with the help of said bolts. A cutter knife 7 is disposed adjacent to the front face of a die plate 5 that forms the distal portion of the die 4. The cutter knife 7 is mounted on the distal portion of a cutter shaft 8, which extends from the cutter drive device M through the insulation/crystallization zone 9.

[0017] This insulation/crystallization zone has a granulation section A and crystallization section B. A heating medium at 100°C is usually fed to the granulation section A to fill the section. Numerous fine holes 6 that open facing the turning face of cutter knife 7 are formed in this die plate 5. The molten resin that has been extruded from these fine holes 6 into the heating medium that circulates in the granulation section A of the insulation/crystallization zone 9 is cut by the cutting knife 7 while being extruded and worked into pellets. The heating medium is conveyed from tank 13 to the granulation section A of the insulation/crystallization zone 9 with the help of a fluid pump 14.

[0018] The saturated polyester resin pellets obtained in this way are conveyed to the temperature-controllable crystallization section B in the same insulation/crystallization zone 9, and crystallization is induced as a result of keeping the saturated polyester resin at a temperature that ranges from the glass transition point (Tg) thereof or higher to the melting point (Tm) thereof or lower.

[0019] The crystallized saturated polyester resin pellets are fed through a line D to a dehydration/drying section C consisting of a cyclone. The pellets are recovered from a recovery port 11 once they have been separated from the heating medium. The heating medium that has been separated from the pellets is returned through a filtration device 12 to a tank 7.

[0020] Figure 4 is a schematic drawing showing the temperature profile during granulation and solid-phase polymerization. In comparison to conventional methods whereby granulation and crystallization are performed in separate steps, as shown in Figure 4, the method for granulating saturated polyester resin using a granulating apparatus that operates on the underwater cutting principle according to the present invention provides excellent operating efficiency and reduces energy loss as a result of allowing saturated polyester resin to be concurrently granulated and crystallized in the same insulation/crystallization zone of a granulating apparatus. Moreover, the pre-crystallization step of solid-phase polymerization is not necessary when the saturated polyester resin pellets obtained by means of the method for granulating saturated polyester resin according to the present invention are used. Moreover, the pellet surface is not render rough as a result of agitation intended to prevent pellet fusion, and situations can be avoided in which powder is produced as a result of the pellets rubbing against each other in response to such agitation. Drawbacks related to interference with molding and other finishing processes can be

overcome, and the problem of interference with molding and other subsequent steps can thereby be solved.

[0021]

[Effect of the Invention] The present invention provides a granulating method and apparatus that afford excellent operating efficiency and reduce energy loss in comparison with conventional methods whereby granulation and crystallization are performed in separate steps, as a result of simultaneously granulating and crystallizing saturated polyester resin in the same insulation/crystallization zone of a granulating apparatus. Moreover, the pre-crystallization step of solid-phase polymerization is not necessary when the saturated polyester resin pellets obtained by means of the method for granulating saturated polyester resin according to the present invention are used. Moreover, the pellet surface is not render rough as a result of agitation intended to prevent pellet fusion, and situations can be avoided in which powder is produced as a result of the pellets rubbing against each other in response to such agitation. Therefore, the problem of interference with the molding and subsequent processes can be eliminated. Furthermore, the method for granulating saturated polyester resin according to the present invention can also be used to granulate micropellets with a pellet diameter of 1 mm or smaller.

[Brief Description of the Drawings]

[Figure 1] A schematic drawing illustrating the steps for granulating and crystallizing a saturated polyester resin, and the main parts of the apparatus according to an example of the present invention

[Figure 2] A schematic drawing showing the main parts of a conventional strand-type granulating apparatus

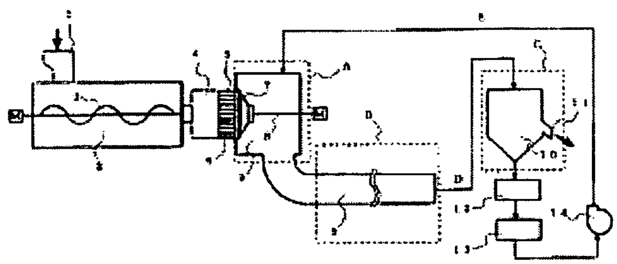
[Figure 3] A schematic drawing showing the main parts of a conventional solid-phase polymerization device

[Figure 4] An explanatory drawing showing an overall comparison of the granulation method according to the present invention and a granulation method consisting of two steps, granulation and crystallization, as a conventional example

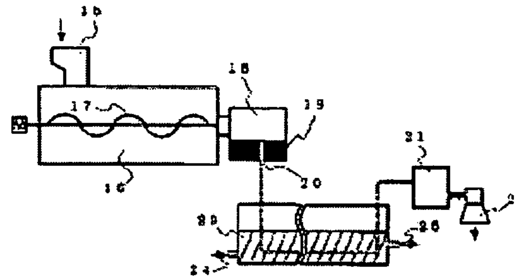
[Key]

1, 15, 27:	Starting material feed port
2, 16:	Kneading sections
3, 17:	Screws
4, 18:	Dies
5, 19:	Die plates
6, 20:	Fine holes
7:	Cutter knife
8:	Cutter shaft
9:	Insulation/crystallization zone
10:	Cyclone
11, 22, 32:	Pellet discharge ports
12:	Filtration device
13:	Tank
14:	Fluid pump
21:	Cutter
23:	Water chamber
24:	Cold fluid feed tube
25:	Cold fluid emission tube
26:	Solid phase polymerization column
28:	Exhaust port
29:	Agitating shaft
30:	Blades
31:	Inert gas feed port
A:	Granulation section
B:	Insulation/crystallization zone
C:	Heating medium removal and drying section
D, E:	Conveyance steps
M:	Drive device

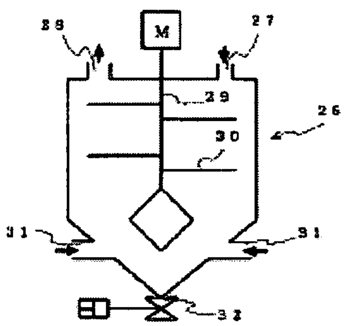
[Fig. 1]



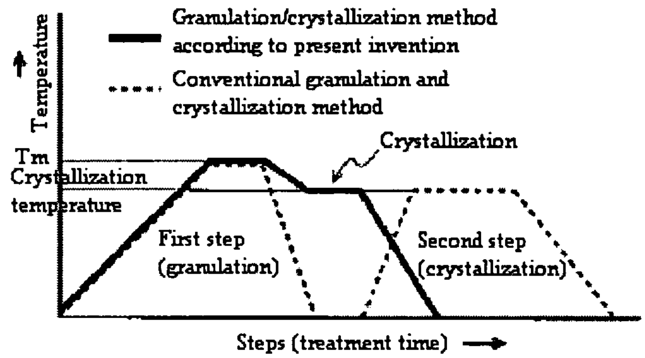
[Fig. 2]



[Fig. 3]



[Fig. 4]



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